SEMI-ANNUAL REPORT

Earthquake and Seismicity Research Using SCARLET and CEDAR

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Investigation

Mechanism Determination of Local Earthquakes Using Waveform and First-Motion Data.

Results

The Pasadena TERRAscope station recorded many small earthquakes around Pasadena. The records can be deconvolved into displacement records. We have developed a method to use these waveform data to determine the mechanism of small events for which first-motion data are incomplete. First-motion data are often incomplete, but they are good enough to constrain the range of allowable solutions. In contrast, the waveform data are of high-quality, but are not enough to determine the mechanisms uniquely. We can combine these two sets of data to determine the mechanisms.

Figure 1 shows the results for the aftershocks of the 1988 Pasadena earthquake.

The P, SV, and SH far field displacements, U_r, U_θ and U_ϕ, from a double-couple point source are given by

$$\begin{bmatrix} U_r \\ U_\theta \\ U_\phi \end{bmatrix} = \frac{M_0 s(t)}{4\pi\rho r\alpha^3} \begin{bmatrix} R^P \\ (\alpha/\beta)^3 R^{SV} \\ (\alpha/\beta)^3 R^{SH} \end{bmatrix} \tag{1}$$

where $s(t)$ and M_0 are the unit moment rate function and the seismic moment, respectively. Here, ρ, α,and β are density, P velocity, and S velocity, and R^P,R^{SV}, and R^{SH} are P-wave, SV-wave and SH-wave radiation patterns, respectively. The radiation patterns are functions of the fault parameters: dip δ, rake λ, and strike ϕ.

Let U_P, U_{SVZ}, U_{SVR} , and U_{SH} be the displacements of the P wave on the vertical component, the SV wave on the vertical component, the SV wave on the radial component, and the SH wave on the tangential component, respectively, observed at the free surface. If we ignore the P-SV conversion at the free surface, then

$$U_r=U_P/(2\cos i_o)$$
$$U_q=U_{SVZ}/(-2\sin i_o)=U_{SVR}/(2\cos i_o)$$
$$U_f=U_{SH}/2,$$

where i_o is the incidence angle.

Although the solution of equation (1) is nonunique, we can determine the range of allowable solutions that explain the observed amplitudes and polarities of P, SV, and SH waves. Figure 1 shows the loci of the P and T axes (hereafter called the inversion P-T loci) of the allowable solutions determined by inverting equation (1). Any solution with a pair of P and T axes on the loci yields the correct amplitudes and polarities of P, SV and SH waves.

The first-motion data were analyzed with the program FPFIT (Reasenberg and Oppenheimer, 1985). The program FPFIT uses a grid-search procedure to find a mechanism by minimizing the normalized, weighted sum of the discrepancies between the observed and theoretical polarity at each station. The program also determines the ranges of P and T axes of mechanisms that fit the first-motion data equally well. These ranges, here called the first-motion P-T ranges, are shown in Figure 1. Since the quality of the first-motion data is limited, the allowable P-T ranges are generally large. Any solution in these ranges are considered acceptable. If the inversion P-T loci pass through the first-motion P-T ranges, any solution for which the P and T axes lie in the overlapping region can satisfy both the first-motion and waveform data. If the inversion P-T loci do not pass through the first-motion P-T ranges, we choose a point on the inversion P-T loci that is closest to the first-motion P-T ranges. Figure 1 shows the points chosen this way, and the resulting solutions (dashed curve); these solutions are compared with those (solid curve) picked by FPFIT using the first motion data alone.

These results will be published in a paper by Ma and Kanamori (1991).

Reference

Ma, K.-F. and H. Kanamori, Aftershock Sequence of the December 3, 1988 Pasadena Earthquake, Bull. Seismol. Soc. of Amer., submitted 1991.

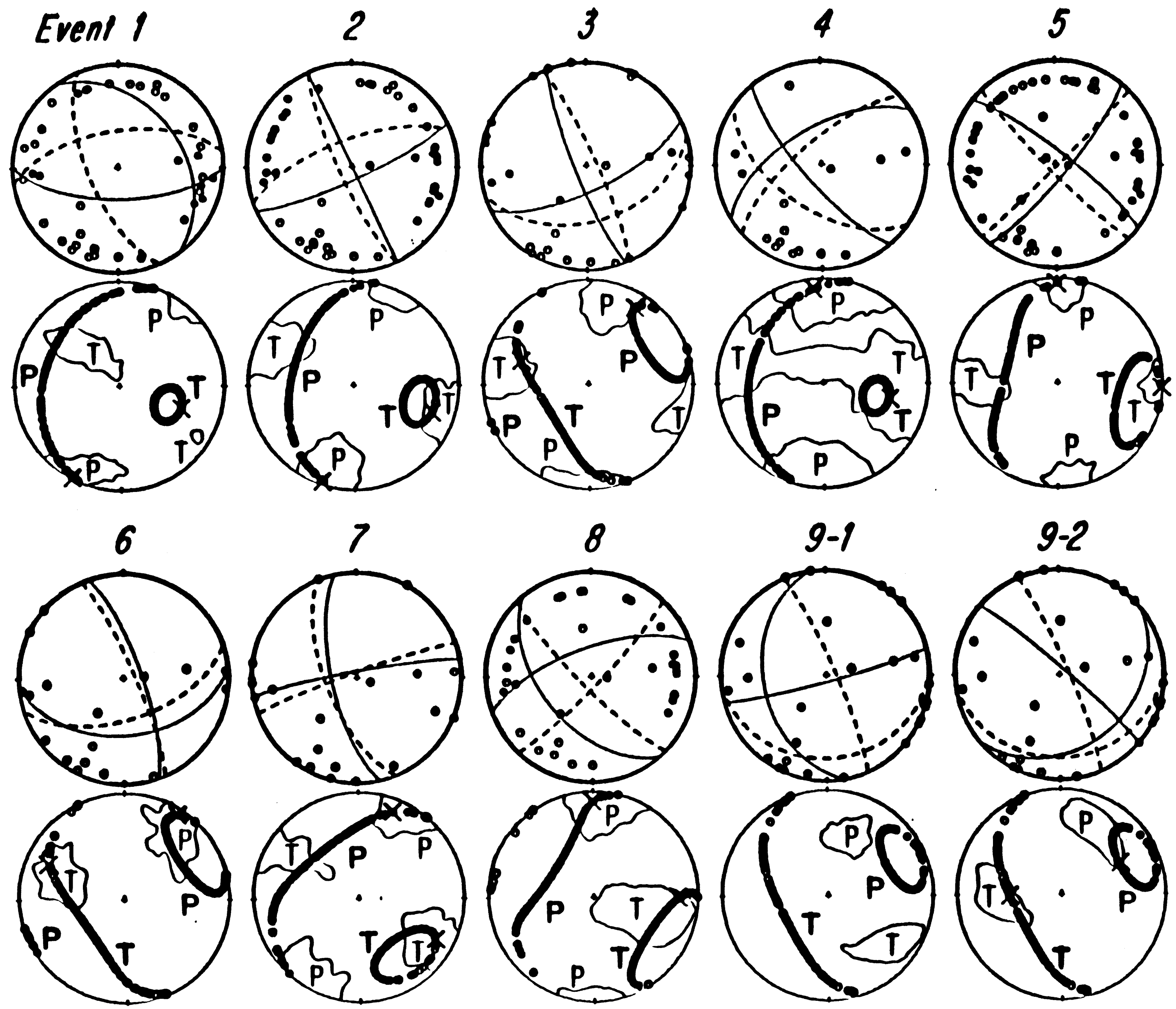

Figure 1